Changes in the density and distribution of birds following possum control on Otago Peninsula:

Community based monitoring of bird fauna outcomes using the slow walk transect method between 2011-2017.

Prepared by Richard Ewans – Eco-South

For the Otago Peninsula Biodiversity Group (OPBG)

21 June 2017

OTAGO PENINSULA BIODIVERSITY TRUST

Eco-South

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Richard Ewans - Eco-South

151 Belford Street, Waverley, Dunedin 9013

Eco-South

Prepared for:

Otago Peninsula Biodiversity Group (OPBG)

P O Box 11, Portobello, Dunedin 9048

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Cover image: Bellbird on Otago Peninsula (photo: C. Hewitt, supplied by Moira Parker)

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1. Introduction and Objectives

The Otago Peninsula Biodiversity Group (OPBG) is a community trust which has been carrying out intensive possum control on the Otago Peninsula since 2011. The aim of the trust is to enhance the biodiversity of the Otago Peninsula by removing possums as a first step towards a long-term goal of making the peninsula pest-free. As of March 2017, over 11,000 possums had been removed from the 9,500 hectare (ha) operational area.

The OPBG has implemented a range of biodiversity monitoring programmes to inform progress towards this goal, including monitoring of bird abundance. The primary purpose of the bird monitoring is to measure changes in the density and distribution of birds resulting from pest control operations.

Possums may impact on bird populations by both competing for resources and direct predation. Possums are generalist and opportunistic feeders and although often primarily herbivorous, will consume invertebrates and birds when available. Frugivorous, herbivorous, insectivorous and nectivorous birds, such as kokako, kereru, tui or bellbird, may increase after control of omnivorous ship rats and brushtail possums due to reduced predation, or increased food, or both (Innes et al, 2010).

Possums usually focus their herbivory on a small set of "key species", and often only target particular individuals of those species at a site which can cause the progressive reduction and elimination of preferred food species (Sweetapple et al. 2004; Nugent et al., 2010, Duncan et al., 2011, Gormley et al., 2012) and even lead or contribute to the collapse of forest canopies over large areas. Possums can also consume large quantities of flowers and fruit.

Possums are significant predators of the eggs, nestlings and sometimes adults of a number of native bird species including species present on Otago Peninsula such as harrier hawk, fantail and kereru/New Zealand pigeon, as well species present elsewhere such as brown kiwi, kokako and saddleback (Innes, 1994). It is highly likely a range of other bird species are also subject to possum predation.

The slow walk transect bird count method (Greene, 2012) can help guide management by measuring changes in bird density and distribution. The method uses repeated counts of birds on pre-determined transect routes to determine trends (an increase or decrease) in the relative abundance of birds and their distribution in the landscape. Combined with result monitoring data (i.e. indices of possum and other pest abundance) outcome monitoring data can answer questions about the effectiveness of management.

The OPBG began establishment of slow walk transect bird count monitoring in 2010 with 20 transects regularly measured since 2012. This report presents the results from the first 7 years of bird monitoring and aims to answer the following question:

'Has a reduction in possum densities coincided with an increase in bird abundance and distribution?'

2. Methodology

2.1 Study area

Otago Peninsula lies to the east of the Dunedin City urban area and is approximately 9,500ha in size. The landform is the eroded flank of an extinct volcano ranging in altitude from sea level to 408m. Originally mostly forested in the recent pre-human era, the current vegetation is a mosaic of pasture with native/exotic shrubland or scrub, remnant native forest patches, small pine plantations and hedgerows, and other vegetation types such as those on wetlands and/or coastal dunes. Pastureland is currently the predominant landcover type.

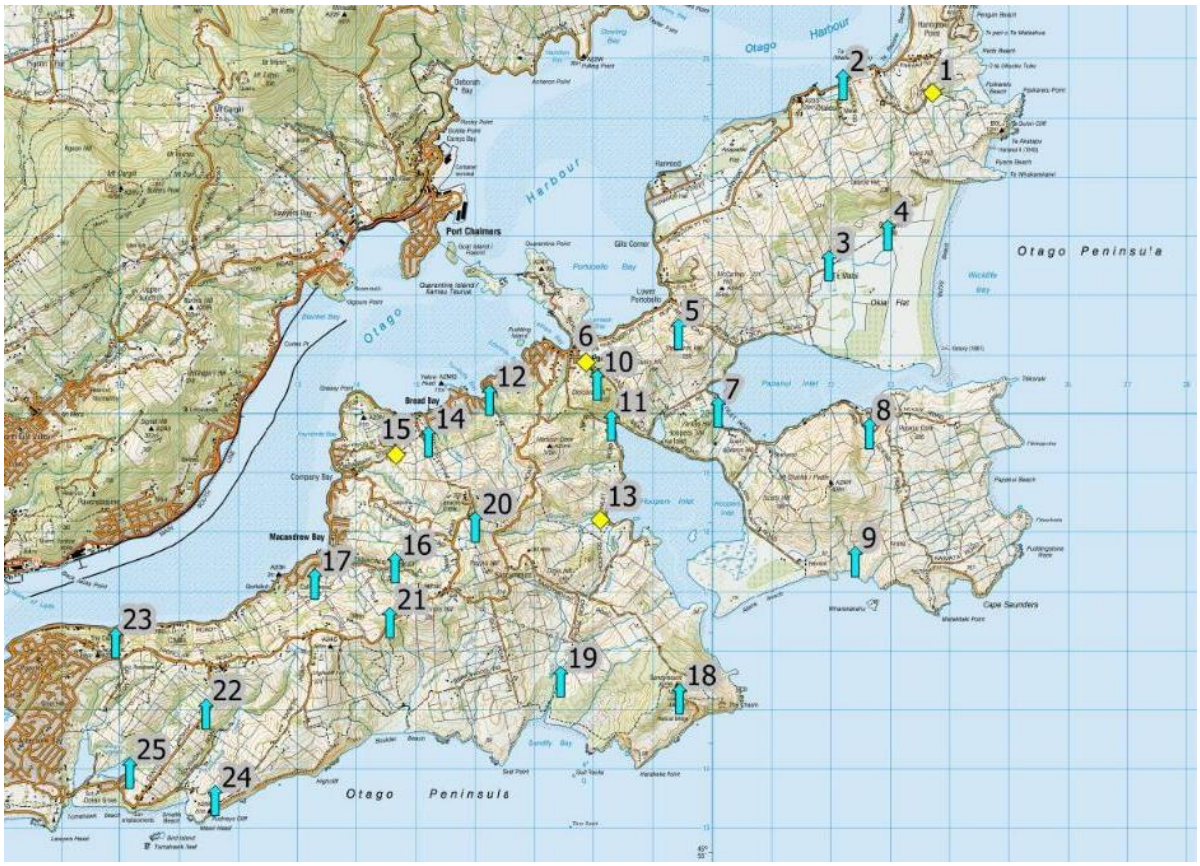
Map 1. Otago Peninsula landscape.

Approximately 5% of the land area on Otago Peninsula currently supports native forest or scrub. The forest is remnant and regenerating podocarp-broadleaved forest with scattered podocarps, primarily Hall's totara (*Podocarpus laetus*) and matai (*Prumnopitys taxifolia*). Other trees characteristic of the forested areas include broadleaf (*Griselinia littoralis*), ngaio (*Myoporum laetum*), kohuhu (*Pittosporum tenuifolium*), lemonwood (*Pittosporum eugenioides*), narrow-leaved lacebark (*Hoheria angustifolia*), lowland ribbonwood (*Plagianthus regius*), mahoe (*Melicytus ramiflorus*), tree fuchsia (*Fuchsia excorticata*) and kowhai (*Sophora microphylla*) (Johnson, 2004).

Otago Peninsula contains a diversity of habitats and is well known for the range of bird species (particularly seabirds and waders) able to be viewed within a relatively small area.

Slow walk bird count transects are located variously in a range of habitat types throughout the peninsula and locations are shown in Map 2 below.

Map 2. Location of slow walk bird count monitoring transects on Otago Peninsula (blue arrows). Yellow diamonds show non-operational transect locations.



2.2 Slow walk bird count transect monitoring

A total of 25 slow walk transects have been established since 2010. Of these; two transects were quickly abandoned (6 & 15), one has been rarely measured (1) and another has never been measured (13). These four transects are not included in this report.

A total of 21 transects are operational, although one is measured relatively infrequently (22) but still included here. Of these; four are in bush habitat, nine in mixed bush and pasture habitat, four in pasture habitat, two in wetland habitat and two in suburban areas.

Transects are planned to be monitored eight times per year (weeks 2 and 3 in September, October and November, and week 4 of April and week 1 of May), however this is rarely the case and different transects are monitored with varying frequencies in each year. Until 2013, transects were planned to be monitored for a minimum of six times per year during between October and early December, and late April/early May. Transects on farmland are not counted in September, due to restricted access during the lambing season.

Transects are generally monitored between one hour after sunrise and 11am. Observers, who are volunteer residents of Otago Peninsula, walk slowly recording all birds seen/heard of 10 main species up to 100m away from the transect. The 10 main species monitored are bellbird, fantail, fernbird, grey warbler, kereru/New Zealand pigeon, magpie, paradise duck, skylark, tomtit and tui. All observers can confidently identify these species.

All other bird species are recorded although there is likely to be some inconsistency around observer expertise for some other species. Each observer is affiliated with a particular transect, although different observers occasionally fill in for regular observers when required. There are 12 observers who have consistently measured their transects since the start of the monitoring. The same volunteer has also coordinated the bird monitoring programme since its inception. New observers are given training on their specific transect, and additional bird identification training and resources.

Leith walk transect/Transect 11 (photo supplied by Moira Parker).

2.3 Data analysis

For each year the number of birds of each species recorded on each transect was averaged across seasonal observations to produce an annual figure. The annual number for each species on each transect was then averaged across the site and plotted with 95% confidence intervals. Results are mapped for common native forest birds and threatened or at risk species for each transect and each year.

A number of bird species recorded are not presented here as observations were either very few, clumped, highly variable, and/or restricted to one or two transects. Species not included here are little owl, Canada goose, rock pigeon, shoveler, black swan, little shag, white-faced heron and pied stilt.

Descriptive statistics were calculated in Microsoft Excel. Graphics work undertaken used the R statistical computing environment (version 3.3.3; R Development Core Team, 2017). Mapping was done using QGIS. Satellite imagery in Map 1 is derived from Google Earth.

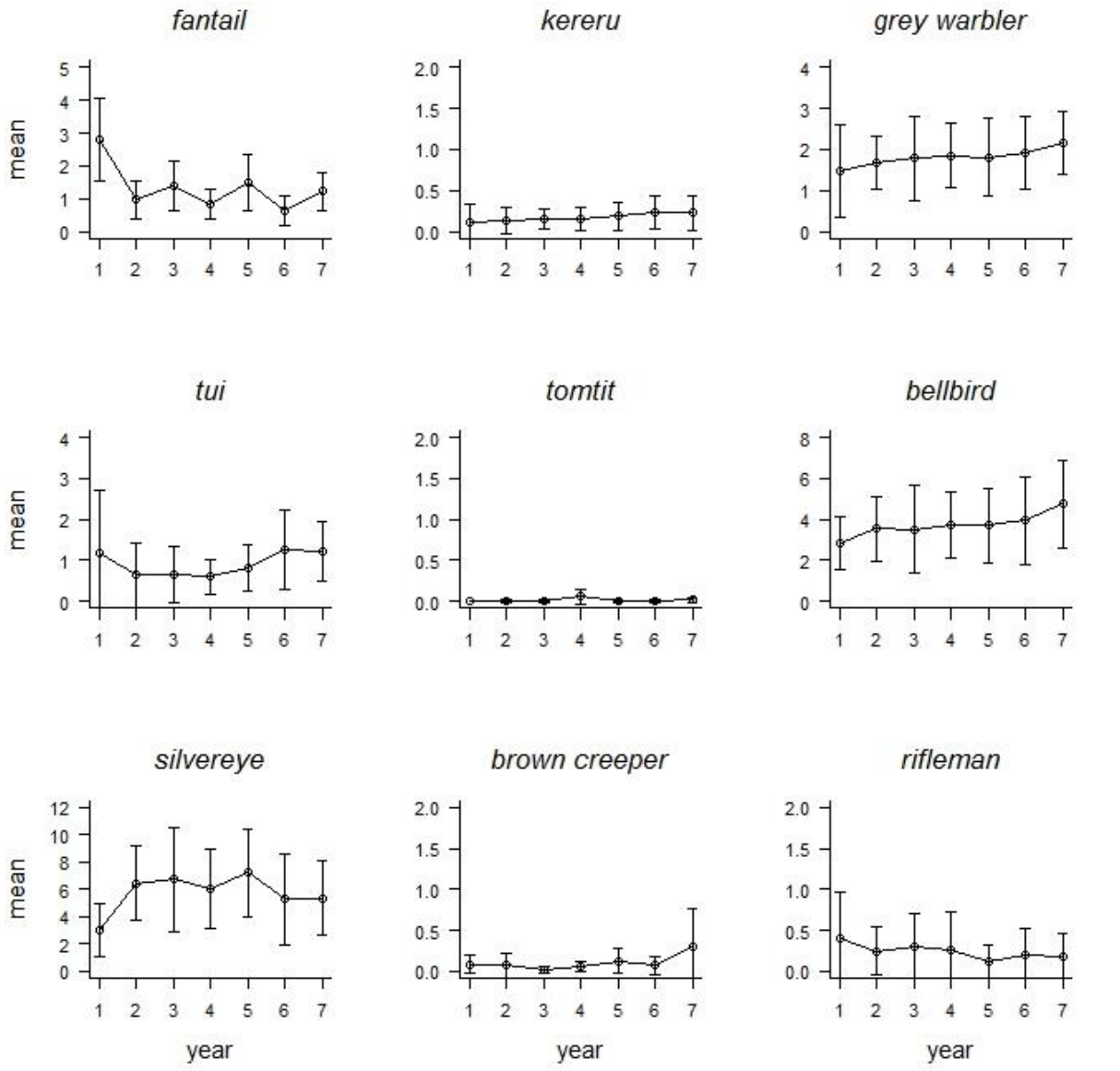
3. Results

3.1 Overall bird abundance

A total of 46 bird species were recorded on transects during the survey period. Of these, 30 species were native or endemic to New Zealand with 16 species introduced and naturalised. A total of 10,121 observations were made of 52,580 birds

Results are presented below in line graphs with the average count per transect for each year. Error bars are 95% confidence intervals and y-axis scales differ between species. Year 1 = 1 July 2010 – 30 June 2011, Year 2 = 1 July 2011 – 30 June 2012, Year 3 = 1 July 2012 – 30 June 2013, Year 4 = 1 July 2013 – 30 June 2014, Year 5 = 1 July 2014 – 30 June 2015, Year 6 = 1 July 2015 – 30 June 2016, Year 7 = 1 July 2016 – 30 June 2017. * denotes introduced bird species.

Figure 1. Mean counts per transect of 9 native forest birds on Otago Peninsula 2010-2017.



Several species of native bird (see Figures 1 & 3) appear to have increased over time e.g. bellbird (mean of 2.8 birds per transect in Year 1 to 4.7 birds per transect in Year 7), grey warbler (mean of 1.4 birds per transect in Year 1 to 2.1 birds per transect in Year 7) and pukeko (mean of 0.6 birds per transect in Year 1 to 1.2 birds per transect in Year 7). Introduced birds (see Figure 2) such as blackbird (mean of 2.8 birds per transect in Year 1 to 4.7 birds per transect in Year 7) and dunnock (mean of 1.6 birds per transect in Year 1 to 3.4 birds per transect in Year 7) also appear to have increased during the survey period.

Species that appear to show a decrease include native species such as spur-winged plover (mean of 1.3 birds per transect in Year 1 to 0.4 birds per transect in Year 7, see Figure 3) and introduced species such as redpoll (mean of 2.7 birds per transect in Year 1 to 1.4 birds per transect in Year 7, see Figure 2) and magpie (mean of 1.3 birds per transect in Year 1 to 0.7 birds per transect in Year 7).

Figure 2. Mean counts per transect of 9 introduced birds on Otago Peninsula 2010-2017.

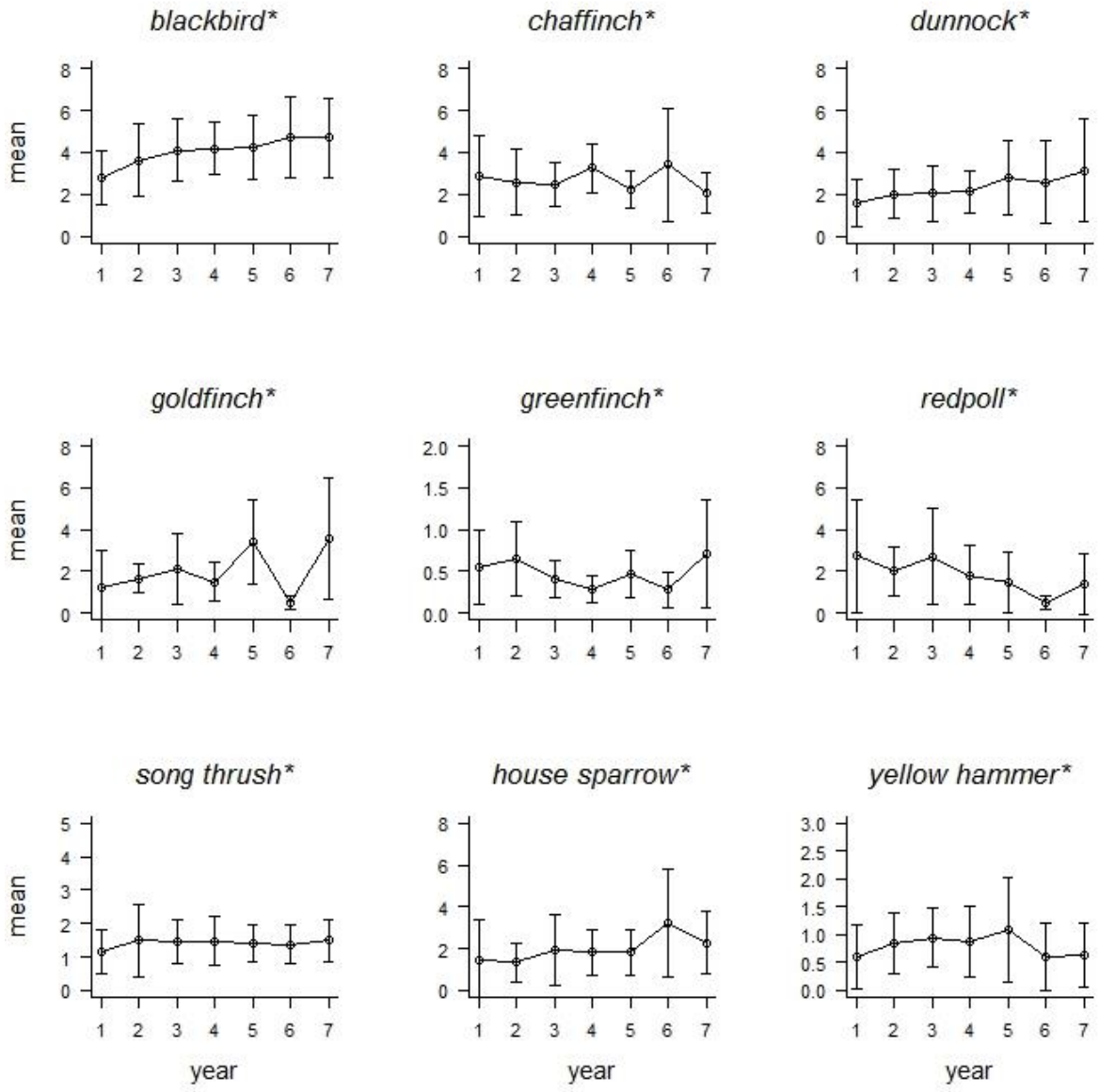


Figure 3. Mean counts per transect of 6 larger birds on Otago Peninsula 2010-2017.

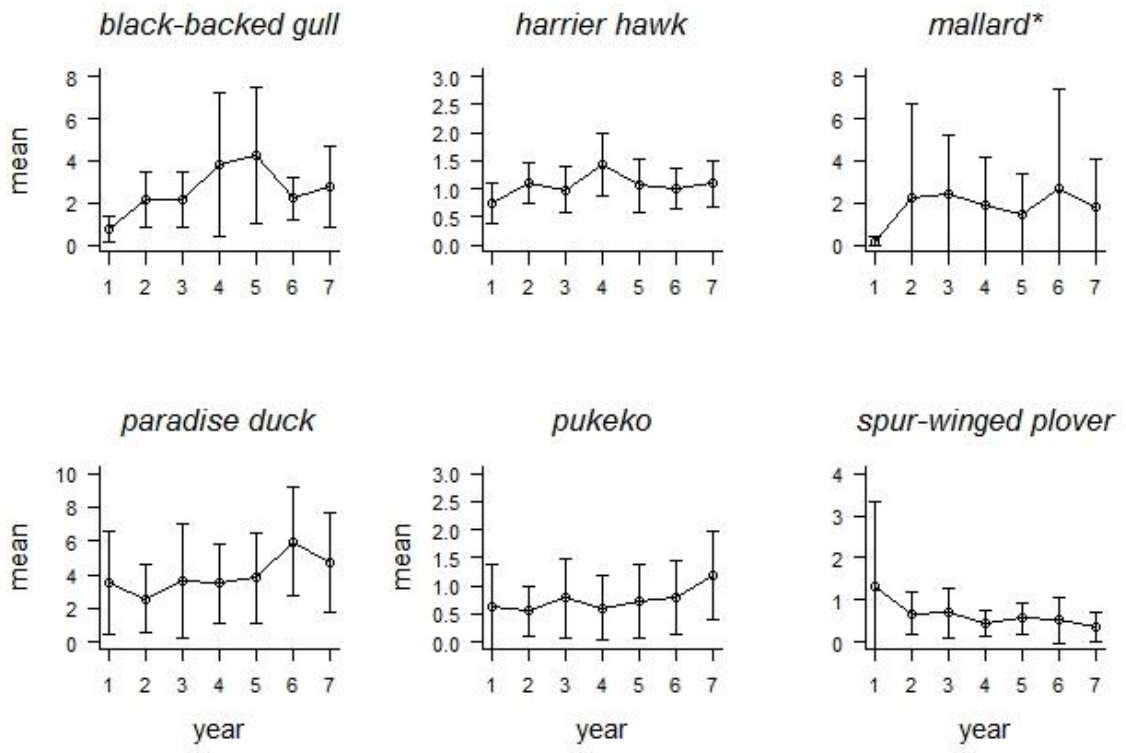
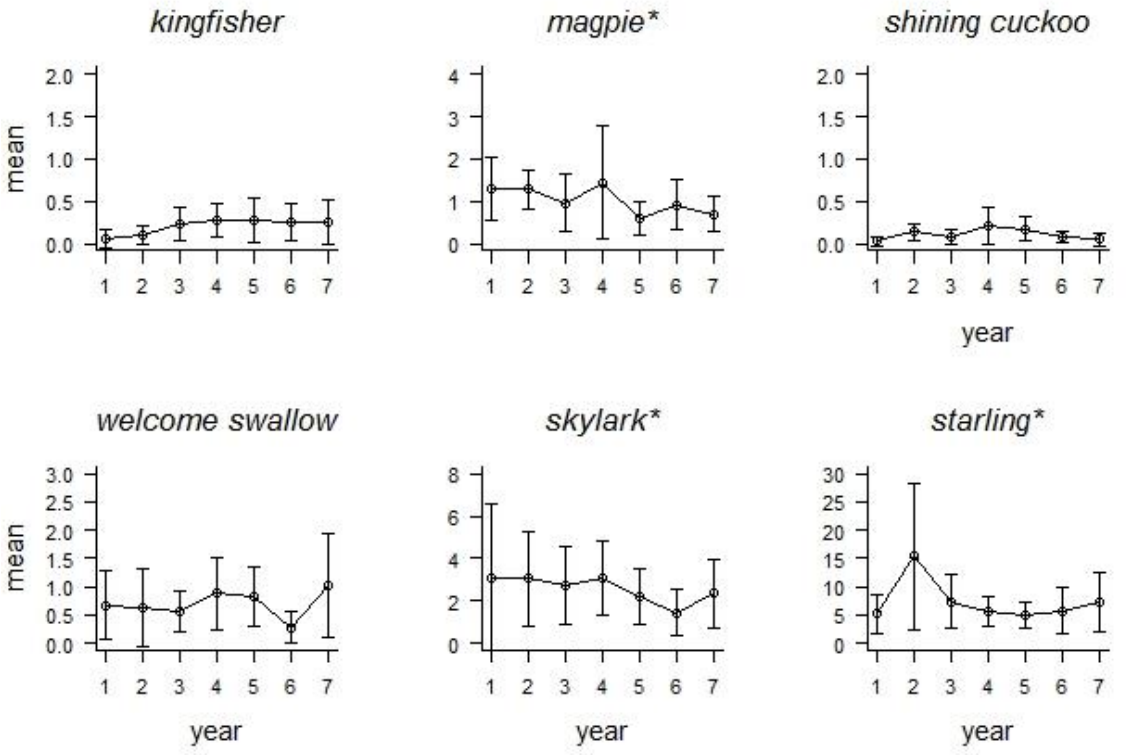


Figure 4. Mean counts per transect of 6 smaller birds on Otago Peninsula 2010-2017.



Few consistent trends can be identified for other species which have either few observations (kingfisher, shining cuckoo, brown creeper, tomtit), large confidence intervals (mallard, paradise duck, skylark, silvereye), or small and/or inconsistent trends (black-backed gull, harrier hawk, welcome swallow, starling, chaffinch, goldfinch, greenfinch, song thrush, house sparrow, yellow hammer, fantail, kereru, tui, rifleman).

3.2 Bird distribution

Maps in Appendix 4 show the annual average number of birds on each transect in Years 2-7 for the native forest bird species in Figure 1. Coloured dot size on the maps is proportional to the annual average number of birds, yellow dots always represent 0 while transects that were not measured in any year are not shown.

3.3 Threatened or at risk species

Numerous 'threatened' or 'at risk' (Robertson et al., 2012) bird species are present on Otago Peninsula including high profile species such as royal albatross and yellow-eyed penguin.

Eight species with a conservation status other than 'not threatened' were recorded on the slow walk transect monitoring. All of these species are classified as 'at risk' (see Table 1) below. The eight 'at risk' species recorded have relatively few observations or are patchily distributed and are shown on maps in Appendix 5.

Table 1. Eight 'at risk' species recorded on OPBG slow walk bird count transects between 2010-2017.

Common name	New Zealand status	Conservation status	Total number of observations
black shag	native	At Risk - naturally uncommon	11
New Zealand falcon	endemic	At Risk - recovering	19
South Island fernbird	endemic	At Risk - declining	32
South Island pied oystercatcher	endemic	At Risk - declining	56
New Zealand pipit	endemic	At Risk - declining	2
red-billed gull	native	At Risk - declining	71
royal spoonbill	native	At Risk - naturally uncommon	7
variable oystercatcher	endemic	At Risk - recovering	5

4. Discussion

4.1 Changes in bird abundance

Slow walk transect bird counts provide a measure of relative (rather than absolute) abundance. Methods such as slow walk transects and five-minute bird counts are called incomplete counts because of the difficulty of distinguishing between a bird being not present or present but not detected when a null observation is recorded.

Bird density may increase and bird distribution expand after possum control due to release from both predation and food competition. However the effect is unlikely to be uniform for all species as different bird species differ in the extent they are vulnerable to the effects of possums. In addition, a range of other introduced predators are likely to be influencing the density and distribution of native birds on Otago Peninsula e.g. rodents (mice, rats), mustelids (weasels, stoats, ferrets), feral cats and hedgehogs.

Several native bird species appear to have increased in abundance over the last few years such as bellbird, grey warbler and pukeko. OPBG receives many anecdotal reports, for example from a landowner seeing tui for the first time on their place in 50 years or a resident noticing that bellbirds seem more abundant over the past 4 years. Several introduced bird species also appear to have increased such as blackbird and dunnock. Other species appear to have declined including native birds such as spur-winged plover.

Results presented here need to be interpreted with some caution. Averaging raw bird count data is not optimal as the data is not normally distributed and zero counts are commonly overrepresented in the data. No analysis has been undertaken to assess the statistical significance of the results as the data requires statistical modelling treatment that is beyond the scope of this report. Statistical modelling procedures are used to distinguish between variation in counts resulting from differing environmental or sampling conditions and variation in the actual number of birds observed to account for the fact that it is not possible to standardise all aspects of surveys between years (Greene, 2012).

In addition, inconsistent data collection can exacerbate the effects of natural variability when averaging bird numbers for the annual transect count e.g. a large group of tui in a kowhai tree in spring on a transect measured only twice in a year will inflate the average for that year compared to a transect that has been measured eight times during the year but still only encounters the one large group of tui. Results from Year 1 in particular should be viewed with caution as many transects were only measured once in that year.

Also, transects are located in a range of habitat types, therefore the site is somewhat stratified and sample numbers (i.e. number of transects) in some habitat types, e.g. wetland, may not be adequate to robustly detect changes across the site. Bird detectability is also different in different habitat types although provided all transects are consistently measured every year this should not influence the data which is relative abundance measure.

The detection of a possum effect on native bird species abundance may not be straightforward. Measuring bird responses to the removal or reduction of a pest mammal can give some indication of the strength of interactions between the species involved (Innes et al., 2010). It is reasonable to propose that such an effect is present as possums are now well known to be opportunistic predators of native fauna and are competitors with many bird species for food. Increases in native bird species such as tui, bellbird, robin, whitehead, and kereru were measured on Kapiti Island after possum control and eventual eradication (Innes et al., 2010) in the presence of rats which were eventually eradicated too.

However, the effect of possums may be relatively small compared to the individual or combined effects of the rest of the predator suite still present on Otago Peninsula such as feral cats, rats and mustelids. For example, the eradications of possums and wallabies from Rangitoto Island were not followed by increases in bird populations (with the possible exception of silvereyes). The remaining ship rats, stoats, cats and commercial honeybees may have sustained predation and/or food shortage (Innes et al., 2010) which may have continued the suppression of bird numbers.

The monitoring transects are split between the two main possum control operational areas and most of the transects are in Sector 4 which has only had possum control since 2013 and therefore only three or four years of low possum densities. Therefore, it is likely that the full effect of removing possums on the bird population will take a longer time to detect.

Attributing trends in bird abundance to the removal of possums may also be complicated by other pest control efforts that target other predators on Otago Peninsula. The extent of such operations is currently unquantified although is unlikely to constitute more than small localised efforts at this stage.

4.2 Changes in possum densities on Otago Peninsula

Possum control operations in Sectors 1-3 (east of the Portobello-Hoopers Inlet Road) were carried out in 2011 and 2012. Possum control operations in Sector 4 (west of the Portobello-Hoopers Inlet Road) were carried out between 2013 and 2015 (OPBG, 2013a). As of March 2017, over 11,000 possums had been removed from the 9,500 hectare (ha) operational area.

Interpretation of trends is limited due to the lack of a non-treatment site and possum density data i.e. pre- and post-control RTC data and history of possum control. Additionally, the relative effects of other predators on the bird population is currently unknown and is likely to be significant. Changes in the density of other predators after possum control is another factor that requires data to inform interpretation of the results of the bird monitoring.

One possible consequence of removing possums is an increase in ship rat abundance, which may directly increase predation on birds, and/or increase food resources to other predators such as stoats. Ship rats compete with possums for food and research in North Island forests has shown that removing possums may result in increased ship rat numbers (e.g. Griffiths & Barron, 2016). However, recent analysis of rat abundance on Otago Peninsula concluded that there has been no detectable increase in rat abundance in association with possum control operations since OPBG began rodent tracking over 5 years ago (Wilson, 2017).

The effect of removing possums on native bird fauna abundance is likely to be most noticeable if possum densities shift from high to very low. Possum density data was unavailable for this report but would add to future analysis and interpretation of results from the slow walk transect data.

4.3 Implementation of slow walk transect methodology

The current set up of the slow walk transects should be adequate to detect changes in native forest bird density and distribution over time at the site. The monitoring project is entirely run by volunteers and there are 12 observers who have consistently measured their transects since the start of the monitoring.

This is a remarkable achievement and is to be congratulated. As is the commitment of the volunteer who has entered all the data since the monitoring began.

However, it is clear that on some transects there is a varying amount of application to collecting the data and it is important to minimise the amount of inconsistency between transects (and years) as much as possible. It is recognised that this can be understandably difficult for community groups and volunteers however the monitoring here requires greater consistency to have the best opportunity to show that controlling possums has benefitted native bird species.

There may be several ways to achieve this. Firstly, consider dropping transect 22 altogether, particularly if it frees up a volunteer to help complete other sites. Secondly, a reminder system for observers and a team of back up observers to substitute in for regular observers when they are unavailable. Thirdly, regularly re-iterate the importance of consistency of data collection to observers. Lastly, discuss the current commitment with observers and establish whether or not it is realistic for everyone. Most transects appear to take less than an hour to complete, plus any travel so the annual commitment for volunteer observers is likely to be around 10 hours per year. If observers can't commit to at least 6 measurements per year then consider replacement observers or shared transects. Rationalisation of transects in habitat types such as pasture could also be considered if it frees up volunteer time elsewhere.

The line transect bird count method is most effective when transects are repeated annually over relatively long time frames (> 10 years), when sample sizes (i.e. number of transects) are high, and when variation in observers, times of day and conditions are minimised (Greene, 2012).

As discussed above the relative effect of possums compared to other predators may be small and difficult to detect with certainty in the short term. However, the slow walk monitoring transects are still very valuable for the project overall as the long term goal is to control other predators on Otago Peninsula, the benefits of which to native birds can be demonstrated by continued monitoring of the transects.

The inherent and inherited nature of the line transect bird count data in this monitoring project requires a more detailed statistical analysis that accounts for zero-inflated count data, inconsistent data collection and natural variability, and utilises data on predator densities. It would be prudent for OPBG to seek relationships over the next few years that may be able to provide such analysis at minimal cost in 2023 or thereabouts. The most likely partners are Otago University teaching staff and/or their postgraduate students in the ecological sciences or statistics departments. The data collected here provides an excellent real-life teaching resource that demonstrates many of the challenges of ecological science and monitoring generally. It also may provide an opportunity to publish results on the effect of removing only possums on a mainland bird population.

5. Conclusions and Recommendations

Few strong trends are discernible from the slow walk bird count transects over the last few years, although there are encouraging signs in the data and anecdotally that bird numbers are increasing for some species.

In ecological terms, it is a relatively short time since possum control began and a number of other predators remain uncontrolled, therefore large increases in bird populations would not be expected at this stage of the programme.

However, it is reasonable to assume that possums have been affecting native bird numbers, although the effects are likely to have varied for different species. A more detailed analysis of the bird count data which accounts for non-normally distributed and inconsistency collected data, and includes pest abundance data would be required to fully investigate the benefits of removing possums for native bird species on Otago Peninsula.

The following recommendations are made to promote the best opportunity to demonstrate that controlling possums has benefitted native bird species:

1. Continue monitoring birds on the slow walk transects but reiterate to volunteers the importance of consistency and ask for a firm commitment to the plan.
2. Remove transects 1, 6, 13, 15 from the programme.
3. After 10 years of possum control across the peninsula e.g. in 2023, undertake detailed analysis using statistical modelling approaches to investigate trends in bird density and distribution.

6. Acknowledgements

The OPBG wish to thank members of the Dunedin Branch of BirdsNZ for their expert advice on a suitable monitoring method, and ecologist Marcia Dale for walking many of the proposed 1k transects and undertaking the mapping.

OPBG are most grateful to Derek Onley for his enjoyable and instructive training sessions and providing the recording sheet and CD of bird calls and songs. Derek kindly reviewed the monitoring data collected from Nov 2011 to Sept 2013 and suggested improvements to the counting procedure.

On the first training day in 2010, Sharyn Broni generously offered to enter all the bird data and has continued ever since. Sharyn has made a huge contribution over the past 6 years, in addition to her own Cape Saunders transect, and OPBG are greatly indebted to her.

And finally, thank you to all those wonderful volunteers who have done their birds counts year in, year out. There are some very competent amateur ornithologists in the team, but mostly they are local residents with a keen interest in birds and an appreciation of the importance of collecting the data.

The author would like to acknowledge and give thanks for the assistance of Sarah Irvine, Sharyn Broni and in particular Moira Parker from OPBG. Colin MacLeod (Otago University Botany Department) also provided assistance to the author.

OPBG bird count volunteers at a training session (photo supplied by Moira Parker).

7. References

Duncan R P, Holland E P, Pech R P, Barron M, Nugent G, Parkes J. 2011. The relationship between possum density and browse damage on kamahi in New Zealand forests. *Austral Ecology 36*: 858 – 869.

Gormley A M, Holland E P, Pech R P, Thomson C, Reddiex B. 2012. Impacts of an invasive herbivore on indigenous forests. *Journal of Applied Ecology 49*: 1296 – 1305.

Greene T. 2012. Birds: incomplete counts – line transect counts Version 1.0. Department of Conservation Inventory and Monitoring Toolbox. http://www.doc.govt.nz/our-work/biodiversity-inventory-and-monitoring/birds/ Accessed 24 November 2016.

Griffiths J W, Barron M C. 2016. Spatiotemporal changes in relative rat (*Rattus rattus*) abundance following large-scale pest control. *New Zealand Journal of Ecology 40*: 371-380.

Innes J, Kelly D, Overton J McC, Gillies C. 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology 34(1)*: 86-114.

Innes J. 1994. The impacts of possums on native fauna. In O'Donnell C F J (comp.). Proceedings of a Workshop on Possums as Conservation Pests. Possum and Bovine Tuberculosis Control National Science Strategy Committee 29-30 November 1994, Christchurch.

Johnson P. 2004. Otago Peninsula Plants: An annotated list of vascular plants growing in wild places. Save The Otago Peninsula (STOP) Inc, Portobello, Dunedin. 94p.

Nugent G, Whitford J, Sweetapple P, Duncan R, Holland P. 2010. Effect of one-hit control on the density of possums (*Trichosurus vulpecula*) and their impacts on native forest. *Science for Conservation 304*. 64p.

Otago Peninsula Biodiversity Group. 2013a. Operational Report May 2010 – June 2013. Otago Peninsula Biodiversity Group, Portobello, Dunedin. 44p.

R Development Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Robertson, H A; Dowding, J E; Elliot, G P; Hitchmough, R A; Miskelly, C M; O'Donnell, C F J; Powlesland, R G; Sagar, P M; Scofield, R P; Taylor, G A. 2013. Conservation status of New Zealand birds, 2012. *New Zealand Threat Classification Series 4*. Department of Conservation, Wellington.

Sweetapple P J, Fraser K W, Knightbridge P I. 2004. Diet and impacts of brushtail possum populations across an invasion front in South Westland, New Zealand. *New Zealand Journal of Ecology 28(1)*: 19-33.

Wilson, D. 2017. Abundance of rats (*Rattus* species) following brushtail possum control operations on the Otago Peninsula. Landcare Research Contract Report: LC2768, Landcare Research, Dunedin. 21p.

8. Other Reading

Greene T C, Pryde M A. 2012. Three population estimation methods compared for a known South Island robin population in Fiordland, New Zealand. *New Zealand Journal of Ecology 36(3)*: 340-352.

Greene T C, Dilks P J, Westbrooke I M, Pryde M A. 2013. Monitoring selected forest bird species through aerial application of 1080 baits, Waitutu, New Zealand. *New Zealand Journal of Ecology 37(1)*: 41-50.

Handford P. 2000. Native Forest Monitoring: A guide for forest owners and managers. Forme Consulting Group Ltd. 183p.

Meadows S, Moller H, Weller F. 2012. Reduction of bias when estimating bird abundance within small habitat fragments. *New Zealand Journal of Ecology 36(3)*: 408-415.

Morgan D K J, Waas J R, Innes J, Arnold G. 2012. Native bird abundance after Australian magpie (*Gymnorhina tibicen*) removal from localised areas of high resource availability. *New Zealand Journal of Ecology (2012) 36(3)*: 333-339.

Otago Peninsula Biodiversity Group. 2013b. Otago Peninsula Biodiversity Trust Bird Monitoring Report December 2013. Otago Peninsula Biodiversity Group, Portobello, Dunedin. 7p.

Sullivan J J. 2012. Recording birds in real time: a convenient method for frequent bird recording. *New Zealand Journal of Ecology 36(3)*: 416-424.

van Heezik Y, Ludwig K, Whitwell S, McLean I G. 2008. Nest survival of birds in an urban environment in New Zealand. *New Zealand Journal of Ecology 32(2)*: 155-165.

Appendix 1. List of birds recorded on Otago Peninsula during slow walk transect counts.

Common name	Scientific name	New Zealand status	Conservation status	Total number of observations
bellbird	*Anthornis melanura*	endemic	not threatened	594
black shag	*Phalacrocorax carbo novaehollandiae*	native	naturally uncommon	11
black swan	*Cygnus atratus*	native	not threatened	28
southern black-backed gull	*Larus dominicanus*	native	not threatened	470
blackbird	*Turdus merula*	introduced - naturalised		740
brown creeper	*Mohoua novaeseelandiae*	endemic	not threatened	26
Canada goose	*Branta canadensis*	introduced - naturalised		1
chaffinch	*Fringilla coelebs*	introduced - naturalised		538
dunnock	*Prunella modularis*	introduced - naturalised		473
New Zealand falcon	*Falco novaeseelandiae*	endemic	recovering	19
South Island fantail	*Rhipidura fuliginosa*	endemic	not threatened	333
South Island fernbird	*Bowdleria punctata*	endemic	declining	32
European goldfinch	*Carduelis britannica*	introduced - naturalised		302
European greenfinch	*Carduelis chloris*	introduced - naturalised		179
grey warbler	*Gerygone igata*	endemic	not threatened	499
harrier hawk	*Circus approximans*	native	not threatened	513
house sparrow	*Passer domesticus*	introduced - naturalised		337
kereru	*Hemiphaga novaeseelandiae*	endemic	not threatened	101
New Zealand kingfisher	*Todiramphus sanctus vagans*	native	not threatened	146
little owl	*Athene noctua*	introduced - naturalised		10
little shag	*Phalacrocorax melanoleucos brevirostris*	native	not threatened	20
Australian magpie	*Gymnorhina tibicen*	introduced - naturalised		315
mallard	*Anas platyrhynchos*	introduced - naturalised		205
paradise duck	*Tadorna variegata*	endemic	not threatened	519
South Island pied oystercatcher	*Haematopus finschi*	endemic	declining	56
pied stilt	*Himantopus leucocephalus*	native	not threatened	18
New Zealand pipit	*Anthus novaeseelandiae*	endemic	declining	2
pukeko	*Porphyrio melanotus*	native	not threatened	214
red-billed gull	*Larus novaehollandiae scopulinus*	native	declining	71
redpoll	*Carduelis flammea cabaret*	introduced - naturalised		244
South Island rifleman	*Acanthisitta chloris chloris*	endemic	not threatened	77
rock pigeon	*Columba livia*	introduced - naturalised		4
shining cuckoo	*Chrysococcyx lucidus*	native	not threatened	79
Australasian shoveler	*Anas rhynchotis*	native	not threatened	14
silvereye	*Zosterops lateralis*	native	not threatened	576
Eurasian skylark	*Alauda arvensis*	introduced - naturalised		375
song thrush	*Turdus philomelos clarkei*	introduced - naturalised		451
royal spoonbill	*Platalea regia*	native	naturally uncommon	7

spur-winged plover	*Vanellus miles novaehollandiae*	native	not threatened	194
European starling	*Sturnus vulgaris vulgaris*	introduced - naturalised		572
South Island tomtit	*Petroica macrocephala macrocephala*	endemic	not threatened	12
tui	*Prosthemadera novaeseelandiae novaeseelandiae*	endemic	not threatened	283
variable oystercatcher	*Haematopus unicolor*	endemic	recovering	5
welcome swallow	*Hirundo neoxena neoxena*	native	not threatened	166
white-faced heron	*Egretta novaehollandiae novaehollandiae*	native	not threatened	48
yellowhammer	*Emberiza citrinella caliginosa*	introduced - naturalised		242

Appendix 2. List of slow walk transects

Transect number	Habitat type*	Transect names	Total number of transect counts		
1	M	Pipikaretu	5		
2	M	Tamatea Rd	46		
3	P	Riddell Rd	76		
4	W	Okia Reserve	49		
5	P	Roselle Farm	27		
6		Allans Beach Rd	0		
7	B	Varleys Hill	58		
8	P	Cape Saunders Rd	57		
9	M	Otapahi	23		
10	B	Dicksons Hill	48		
11	M	Leith Walk	54		
12	M	Bacon St	40		
13		Ara Kotare	0		
14	P	Camp Road	35		
15		McTaggart Street	2		
16	M	Greenacres St	76		
17	S/B	Howard St	41		
18	M	Sandymount	29		
19	P	Ridge Road	33		
20	M	Peggy's Hill	26		
21	M	Paradise Track	48		
22	M	Centre Road	13		
23	S	Irvine Rd	35		
24	P	Karetai Track	20		
25	W/B	Tomahawk	27		

* B=bush, P=pasture, M=mixed bush and pasture, W=wetland, S=suburban.

Appendix 3. Map of slow walk transects

Note transects 1, 5, 7, 9, 10, 13 and 23 are on private land and not shown on this map. Transects 6 and 15 are no longer monitored.

Appendix 4. Maps of common native forest bird species recorded

Maps of the density and distribution common native forest bird species are provided in a separate appendix booklet for Years 2-7. Observations are coloured differently for each bird species with the annual average of the number of individuals counted on each transect represented by different sized dots. Yellow dots always represent 0 while transects that were not measured are not shown.

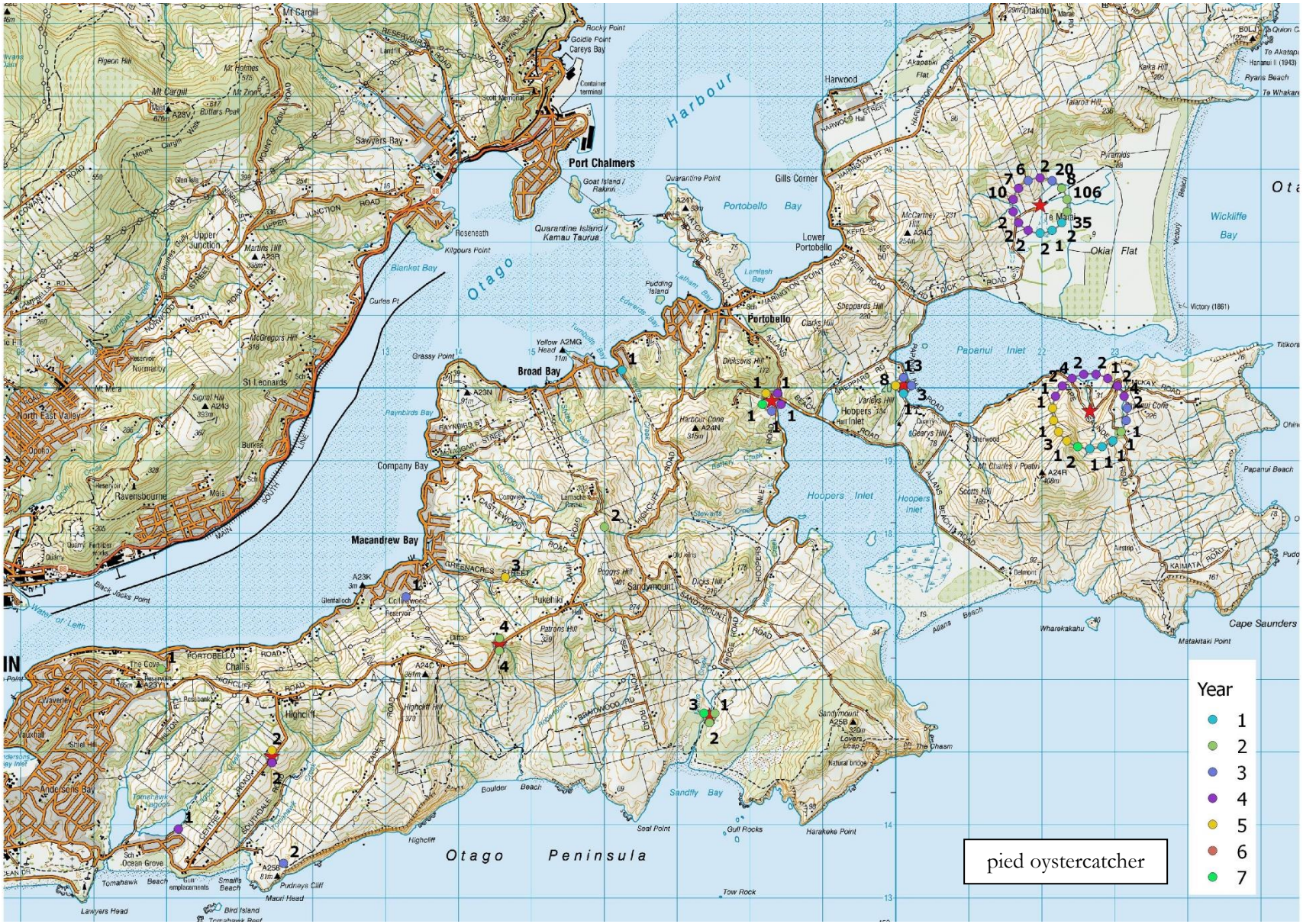
Appendix 5. Maps of 'at risk' species recorded

Maps of all observations of 'at risk' bird species are provided below. Observations are coloured differently for each year (see legend on each map) with the number of individuals shown next to each observation point. Red stars show the location of the transect while the coloured dots represent the observations for each transect.


Year
1
2
3
4
5
6
7
black shag
Otago Peninsula
Otago Harbour
Port Chalmers
Portobello
Broad Bay
Macandrew Bay
Company Bay
Harwood
Papanui Inlet
Hoopers Inlet
Sandfly Bay
Cape Saunders
Wickliffe Bay
Okia Flat
Highcliff
Tomahawk Beach
Ocean Grove
Sawyers Bay
Ravensbourne
St Leonards
Quarantine Island / Kamau Taurua
Goat Island / Rakiriri
Portobello Bay
Lower Portobello
Sandymount
Pukehiki
Boulder Beach
Allans Beach
Andersons Bay
Mt Cargill
Harbour Cone
Seal Point
Gull Rocks
Harakeke Point
Lawyers Head
Smaills Beach
Maori Head
Blanket Bay
Grassy Point
Broad Bay
North East Valley
Portobello Road
Highcliff Road
Harington Point Road


Year
1
2
3
4
5
6
7
falcon


Year
1
2
3
4
5
6
7
fernbird


Harbour
Otago
Port Chalmers
Portobello
Broad Bay
Macandrew Bay
Company Bay
Hoopers Inlet
Papanui Inlet
Otago Peninsula
Cape Saunders
Wickliffe Bay
Portobello Bay
Blanket Bay
Sandfly Bay
Boulder Beach
Harwood
Gills Corner
Lower Portobello
Okia Flat
Broad Bay
Sandymount
Highcliff
Andersens Bay
Ocean Grove
Year
1
2
3
4
5
6
7
pied oystercatcher

Mt Cargill
Harbour
Port Chalmers
Sawyers Bay
Careys Bay
Container terminal
Goat Island / Rakiriri
Quarantine Island / Kamau Taurua
Quarantine Point
Portobello Bay
Gills Corner
Harwood
Lower Portobello
Roseneath
Blanket Bay
Otago
Pudding Island
Portobello
Te Matai
Okia Flat
Wickliffe Bay
Papanui Inlet
Broad Bay
Grassy Point
St Leonards
Ravensbourne
North East Valley
Company Bay
Harbour Cone
Hoopers Inlet
Macandrew Bay
Sandymount
Pukehiki
Cape Saunders
Challis
Highcliff
Boulder Beach
Sandfly Bay
Seal Point
Gull Rocks
Otago Peninsula
Ocean Grove
Tomahawk Beach
Smaills Beach
Lawyers Head
Andersons Bay
Waverley
Vauxhall
Year
1
2
3
4
5
6
7
pipit


red-billed gull
Year
1
2
3
4
5
6
7
Otago Harbour
Otago Peninsula
Port Chalmers
Portobello
Broad Bay
Macandrew Bay
Harwood
Okia Flat
Papanui Inlet
Hoopers Inlet
Sandfly Bay
Cape Saunders


spoonbill
Year
1
2
3
4
5
6
7
Otago Harbour
Otago Peninsula
Port Chalmers
Portobello
Broad Bay
Macandrew Bay
Company Bay
Harwood
Papanui Inlet
Hoopers Inlet
Wickliffe Bay
Okia Flat
Cape Saunders
Sandfly Bay
Highcliff
Sandymount
Pukehiki


variable oystercatcher
Year
1
2
3
4
5
6
7
Otago Harbour
Otago Peninsula
Port Chalmers
Portobello
Broad Bay
Macandrew Bay
Company Bay
Harwood
Papanui Inlet
Hoopers Inlet
Wickliffe Bay
Cape Saunders
Sandfly Bay
Portobello Bay
Quarantine Island / Kamau Taurua
Goat Island / Rakiriri
Blanket Bay
St Leonards
Ravensbourne
North East Valley
Highcliff
Sandymount
Tomahawk Lagoon
Ocean Grove
Andersons Bay
Allans Beach
Boulder Beach
Seal Point
Harakeke Point
Mt Cargill
Sawyers Bay
Roseneath
Okia Flat
Te Matai
Harbour Cone
Lower Portobello
Otakou
Pukehiki
Broad Bay
Company Bay